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# Energetic Valorization of Biomethane Produced from Cow-Dung

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## Abstract

The anaerobic digestion offers an advantageous alternative to landfilling, incineration and composting since it is considered as the most appropriate treatment solution. Indeed, the biogas naturally produced by the fermentation of organic waste into anaerobic digesters, contains between 40 and 60% of methane, which gives it fuel character and its valorisation allows energy conservation while protecting the environment by reducing the greenhouse gases emission. This process corresponds perfectly to the policy of sustainable development. The objective of this paper is to popularize the technique of organic waste biomethanisation or anaerobic digestion in order to produce renewable energy and cleaner environment through the exploitation of research results.

In this work, we used as support the experimental results obtained in the laboratory. The mesophilic anaerobic digestion of cow-dung, into an experimental digester of 800 liters capacity, has produced 26.478 m<sup>3</sup> of biogas for 77 days with an average optimal composition of 61% in methane and energy equivalent to 592.8 MJ (164.5 kWh). These results are hopeful for the use of cattle wastes mass available in Algeria, or even household wastes.

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**Keywords:** Biogas ; cow-dung ; anaerobic digestion ; energetic valorisation.

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## 1. Introduction

Anaerobic digestion is an attractive waste treatment practice in which both pollution control and energy recovery can be achieved. Many agricultural and industrial wastes are ideal candidates for anaerobic digestion because they contain high levels of easily biodegradable materials [1-3].

This process is found in many naturally occurring anoxic environments including watercourses, sediments, waterlogged soils, etc. It can also be applied to a wide range of feedstocks including industrial and municipal waste waters, agricultural, municipal, food industry wastes, and plant residues [4-6].

The production of biogas through anaerobic digestion offers significant advantages over other waste treatment practices, including less biomass sludge, effectiveness of pathogen removal, minimizing odor emissions, production of slurry as an improved fertilizer, etc. [2].

However, methane and CO<sub>2</sub> produced through the process are greenhouse gases and they should be confined to prevent their dispersal into the atmosphere. On average, the methane produces three times less CO<sub>2</sub> than conventional aerobic fermentation. The combustion of produced methane emerged water vapor and a small amount of CO<sub>2</sub>. In the example of an industrial plant perfectly controlled, the biogas contributes to the protection of the ozone layer and is a source of renewable energy.

Today in Algeria, the use of biogas technology would solve the problem of waste management conserving the in parallel fossil fuels and establishing a society based on recycling and not on waste. Indeed, the biogas produced naturally by the fermentation of organic waste under anaerobic (closed digesters), contains between 40 and 60% methane, with its fuel characteristics meeting a number of economic, ecological and energy concerns. From a global point of view, energy recovery of biogas reduces the use of fossil fuels and their impact on the environment which corresponds perfectly to the policy of sustainable development.

The aim of this paper is to popularize the technique of anaerobic digestion of organic wastes, including cow-dung, for renewable energy production and environmental sanitation through the valorisation of research results obtained in the laboratory.

### 1.1. Biogas valorization modes and purification

Biogas is practically converted into useful forms of energy and can be applied in several ways:

- Direct use in boiler (heat, hot water or steam production)
- Power generation
- Production of heat and electricity by cogeneration
- Natural gas after purification
- Motorcar fuel after purification and compression

At the stage of research and development can be mentioned also the following: hydrogen production, fuel cell, refrigeration production by absorption.

The biogas valorization is only possible for larger units (engineered landfills). Several processes can be used in this case:

- Flaring, which involves only the burning of gas. It is a means of safety, since it limits the impact of biogas on the greenhouse effect.
- Combustion under boiler, it is a question of burning the gas in order to extract heat, possibly used by a nearby institution.
- Electricity production. However, the biogas has to contain at least 40% of methane and have a minimum flow rate of 500 m<sup>3</sup>/hour. The electricity production can be coupled with that of heat in the case of cogeneration.

It is important to mark that the calorific value of 1 Nm<sup>3</sup> of biogas containing 60% of methane is about 22 MJ or 6 kWh/m<sup>3</sup>.

Whatever the final use of biogas, it is almost impossible to use it as produced or recovered. The only vaporizable fraction is methane which is contained in more or less big proportions while other components are useless, annoying, and even harmful.

One or several stages of purification are thus necessary according to the mode of valorisation (table 1):

Table 1. Stages of purification versus valorisation mode

Valorisation mode	Elements to remove
Heat production	Water, sulfur ( $H_2S$ )
Electricity production	Water, sulfur ( $H_2S$ ), halogenated organic
Fuel production	Water, sulfur ( $H_2S$ ), halogenated organic, carbon ( $CO_2$ ), metals
Gas network production	Water, sulfur ( $H_2S$ ), halogenated organic, carbon ( $CO_2$ ), metals, oxygen

It should be emphasized that anaerobic digestion is characterized by an interesting energy balance because it produces 4.5 times the consuming energy. One ton of organic waste provides 100 m<sup>3</sup> to 160 m<sup>3</sup> of biogas, the equivalent of 60 to 100 liters of gasoline. By valuing it in the form of heat and power, we obtain 170 kWh electricity and 340 kWh hot water. This technique of waste and polluting effluents treatment presents the very particular characteristic to produce some energy instead of burning it.

## 2. Experimental set up

The experimental setup used in this work consists of a bioreactor called digester with a capacity of 800 liters having a cylindrical shape (1.65 m high and 1.25 m diameter) and a gasometer bell used for biogas storage. The latter is equipped with a gas counter installed upstream to allow quantification of the produced biogas. The heating of the digestion substrate to a temperature equal to 37°C is ensured by a water heater and a warm water circulation pump in closed circuit. In addition, homogenization of the substrate during experiments is done by hand stirrers introduced inside the bioreactor.

Once the digester is fed with 440 kg of diluted (30%) and homogenized cow-dung, it has to be closed in order to create an anaerobic environment necessary for the anaerobic digestion process.

## 3. Results and discussion

### 3.1. Substrate characterization before anaerobic digestion

The main parameters studied for characterization of organic substrates used during anaerobic digestion are carbon and nitrogen as well as their ratio C/N. The chemical characterization of the used cow-dung presented a content of 30% in organic carbon which is the fermentable fraction of the digestion substrate, and approximately 0.023% in content of total nitrogen (with a protein fraction estimated at 1.28 mg/g).

Therefore, the ratio of these two elements ( $C/N = 282/1.28$ ), as seen in table 2, is equivalent to 220. This value is very high compared to the optimum margin between 20/1 and 30/1 described as particularly advantageous for the biogas production. [7]

Table 2. Chemical characterization of cow-dung

Moisture (%)	Organic carbon (mg/g)	Total nitrogen (mg/g)	Protein nitrogen (mg/g)	Total acidity (%)	pH
86	282	0.22	1.28	2.1	5.93

### 3.2. Quantitative characterization of produced biogas

The anaerobic digestion process is a set of biological reactions under the bacteria action, organized into several microbial populations, each of them playing successive roles for the transformation of complex organic mass into methane and carbon dioxide. All reactions, multiple and complex, that take place in the digester can be divided into four main stages characterizing the action of different bacteria groups: hydrolysis, acidogenesis, acetogenesis, methanogenesis [9].

The biogas production during anaerobic digestion process reached a cumulative volume of 26.9 m<sup>3</sup> after a residence time of 77 days, which is a content equivalent to 0.061 liter of biogas per kg of cow dung with an average fraction of 61% in CH<sub>4</sub> [8].

It is observed that the kinetic of production is divided into three main phases (figure 1):

- Latency phase (0 to 10 days), very low daily production was recorded, ranging between 0.006 and 0.056 m<sup>3</sup>. This period corresponds to the liquefaction phase where hydrolysis, acidogenesis and acetogenesis take place.
- Exponential phase (from 11<sup>th</sup> to 65<sup>th</sup> day), also called gasification phase or methanogenesis which correspond to the optimal production of biogas. High daily production of biogas is counted from 0.2 to 0.9 m<sup>3</sup>.
- Level phase (beyond 66 days), production is slow, probably due to exhaustion of digestion substrate.

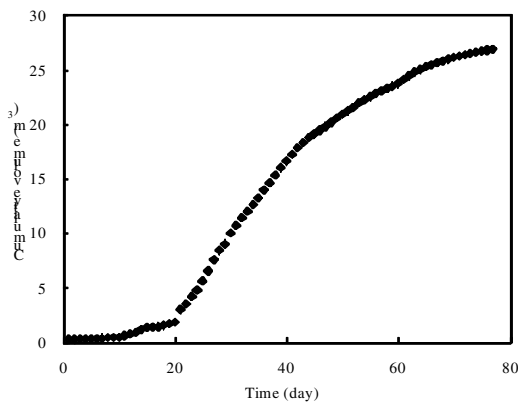


Fig 1. Kinetic of produced cumulative biogas

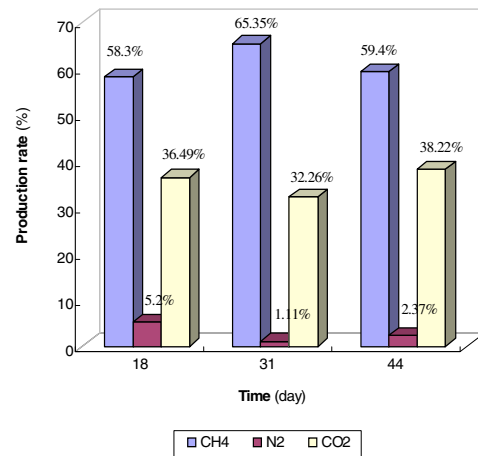


Fig. 2. Composition of produced biogas

### 3.3. Qualitative characterization of produced biogas

Samples taken from the biogas produced during the experiments are analyzed by gas chromatography. The chromatograph used is of type HP 5890 Series II, equipped with a filaments thermal conductivity detector TCD.

The optimum composition of methane was obtained during the period of high production; it represents 65.35% of total volume in crude biogas. A proportional relationship seems to be established between the biogas production and the quality of its composition.

In fact, analysis of the sample taken at the 31<sup>st</sup> day shows that the produced biogas is of better quality, with a maximum concentration of CH<sub>4</sub> in the range of 65.35% and a minimum content of both CO<sub>2</sub> and N<sub>2</sub> 32.26% and 1.11%, respectively (figure 2).

#### 4. Conclusion

The use of methane produced from biogas as a fuel meets a number of economic, ecological and energy concerns. Therefore, biogas can be considered as a renewable green energy as opposed to fossil fuels. The fermentation of 440 kg of cow-dung in a 800 liter digester gave biogas production of 26.9 m<sup>3</sup> with an average content of 61% in CH<sub>4</sub>, value considered optimal and energy equivalent to 592.8 MJ (164.5 kWh ). These results are encouraging for the use of cattle waste mass available in Algeria or even household waste.

#### 5. References

- [1] Mata-alvarez J, Macé S, Llabrés P. Anaerobic digestion of organic solid wastes—an overview of research achievements and perspectives. *Bioresource Technology* 2000;74:3–16.
- [2] Ward Alastair J, Hobbs Phil J, Holliman Peter J, Jones David L. Optimisation of the anaerobic digestion of agricultural resources. *Bioresource Technology* 2008;99:7928–7940.
- [3] Wyman CE, Goodman BJ. Biotechnology for production of fuels, chemicals and materials from biomass. *Applied Biochemistry and Biotechnology* 1993;39:41–59.
- [4] Zhang R, El-Mashad H M, Hartman K, Wang F, Liu G, Choate C, Gamble P. Characterization of food waste as feedstock for anaerobic digestion. *Bioresource Technology* 2007;98:929–935
- [5] Zupancic G D, Uranjek-Zevart N, Ros M. Full-scale anaerobic co-digestion of organic waste and municipal sludge. *Biomass and Bioenergy* 2008;32:162–167.
- [6] Macias-Corral M, Samani Z, Hanson A, Smith G, Funk P, Yu H, Longworth J. Anaerobic digestion of municipal solid waste and agricultural waste and the effect of co-digestion with dairy cow manure. *Bioresource Technology* 2008;99:8288–8293.
- [7] Ludwig S. *L'installation de Biogaz, étude et détails d'installations simples*. GATE, Allemagne. 89 p., 1986
- [8] Igoud S, Tou I, Kehal S, Mansouri N, Touzi A. Première approche de la caractérisation du biogaz produit à partir des déjections bovines. *Rev. Energ. Ren.* 2002;4:123-128.
- [9] Lagrange B. *Biométhane.1. Une alternative crédible*. Ed. EDISUD. 204 p, 1979.